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From Stucco to Stairwells: Inferring Attributes and Floorplans from Limited Geospecific Data

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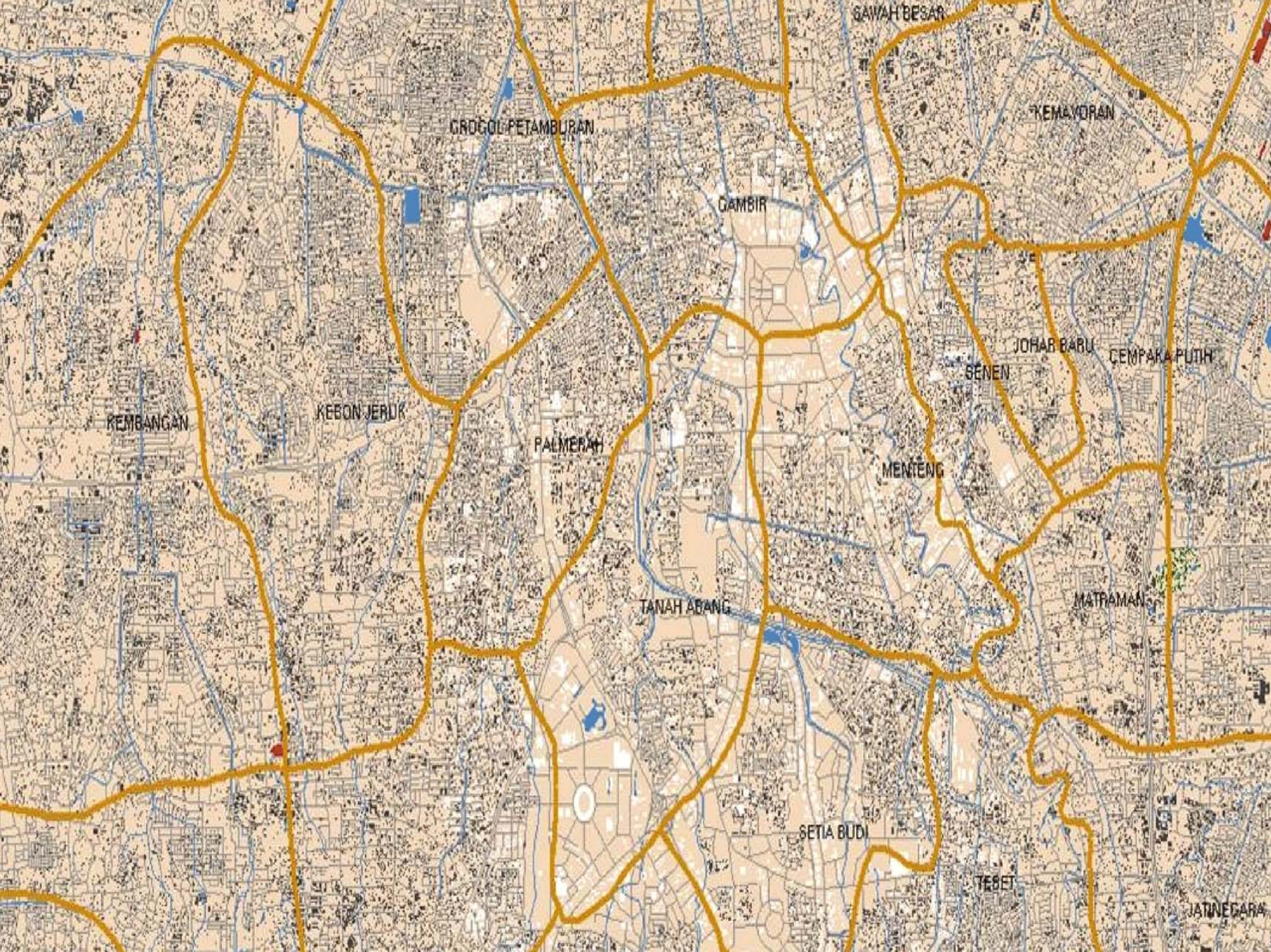
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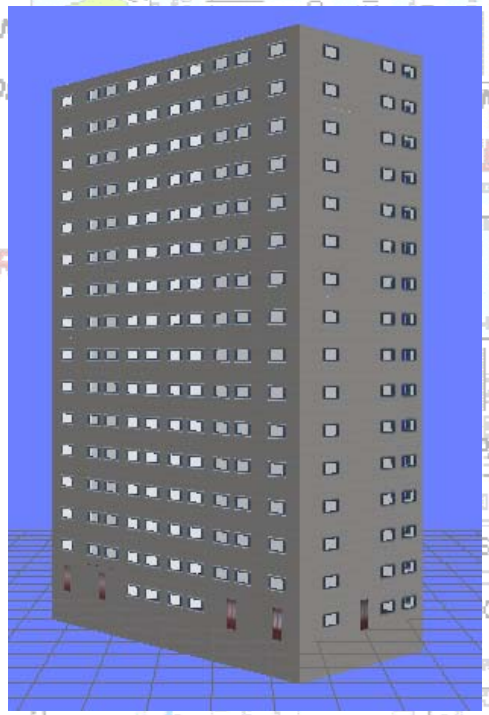
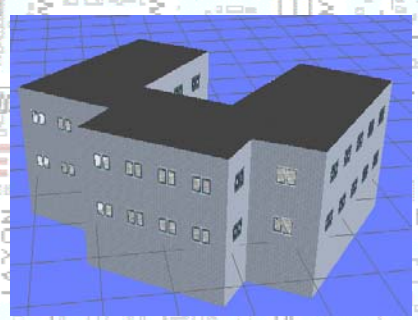
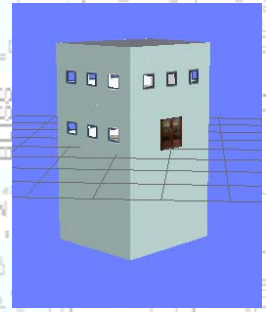
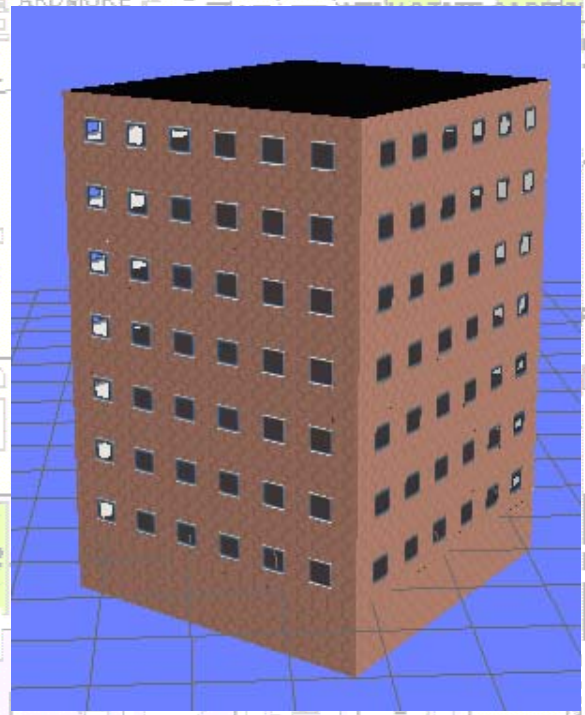
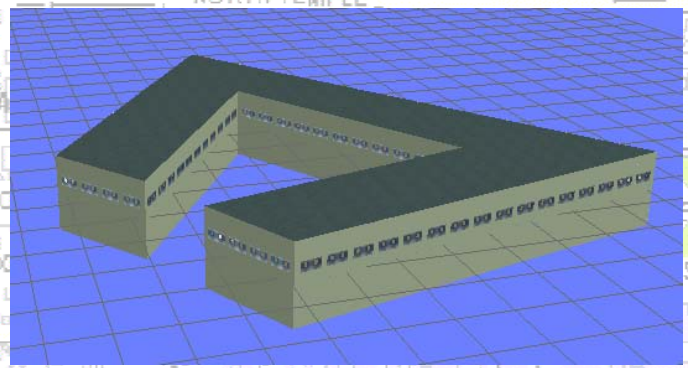
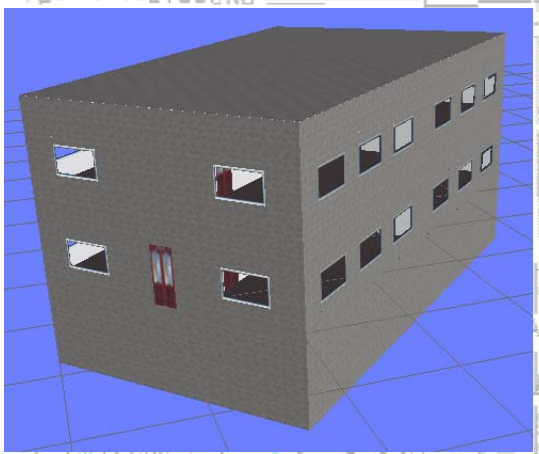


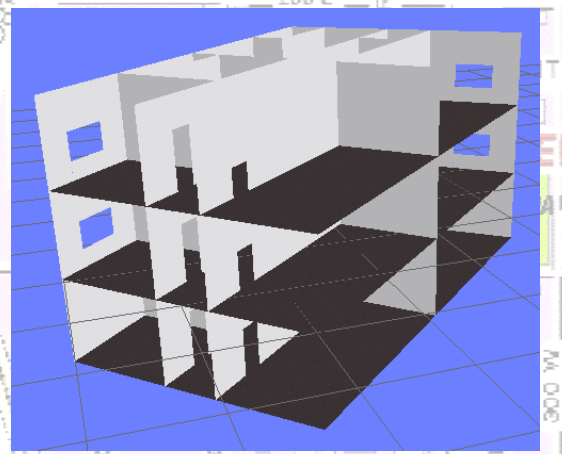


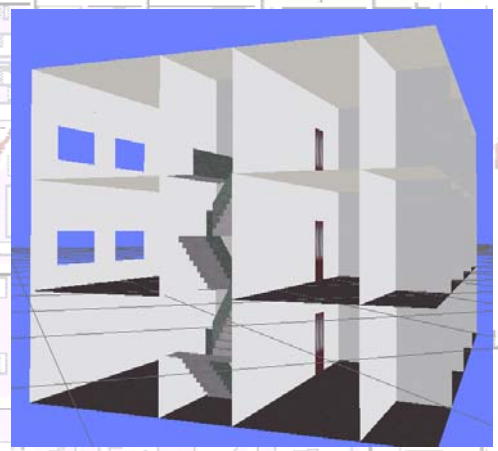












Outline

- Requirements
- Urban Terrain Zones (UTZ)
- Statistical Geotypical Building Attribution
- Geotypical Building Interior Configuration Layout

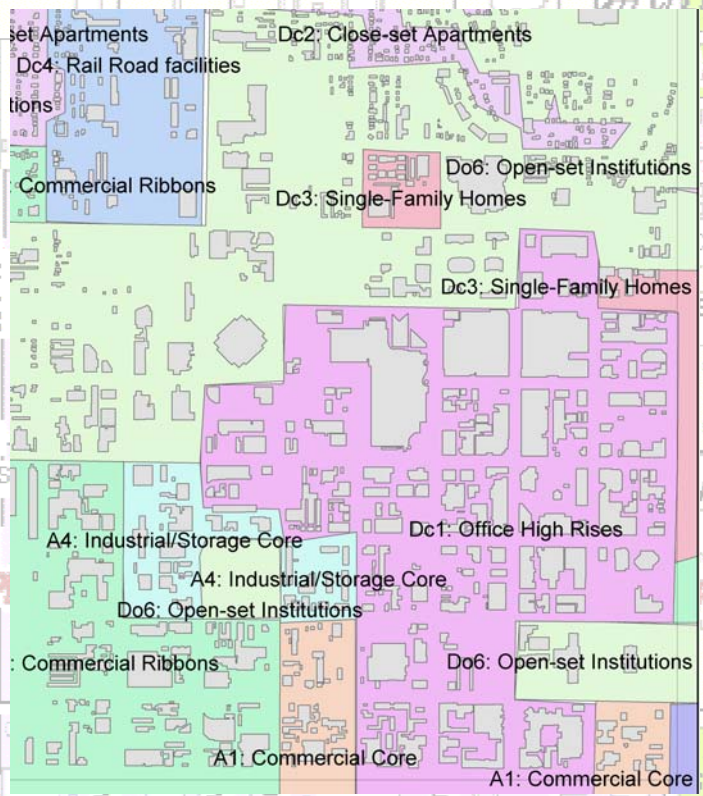
(Stucco and Stairwell) Inferencing Requirements

- Fully data driven
- Tunable to any geo-region
- All input geospecific attribution preserved
- Scaleable to real-world sized cities
- Must be executable as a fully automated process
- User must be able to override any aspect of the process

UTZs Defined

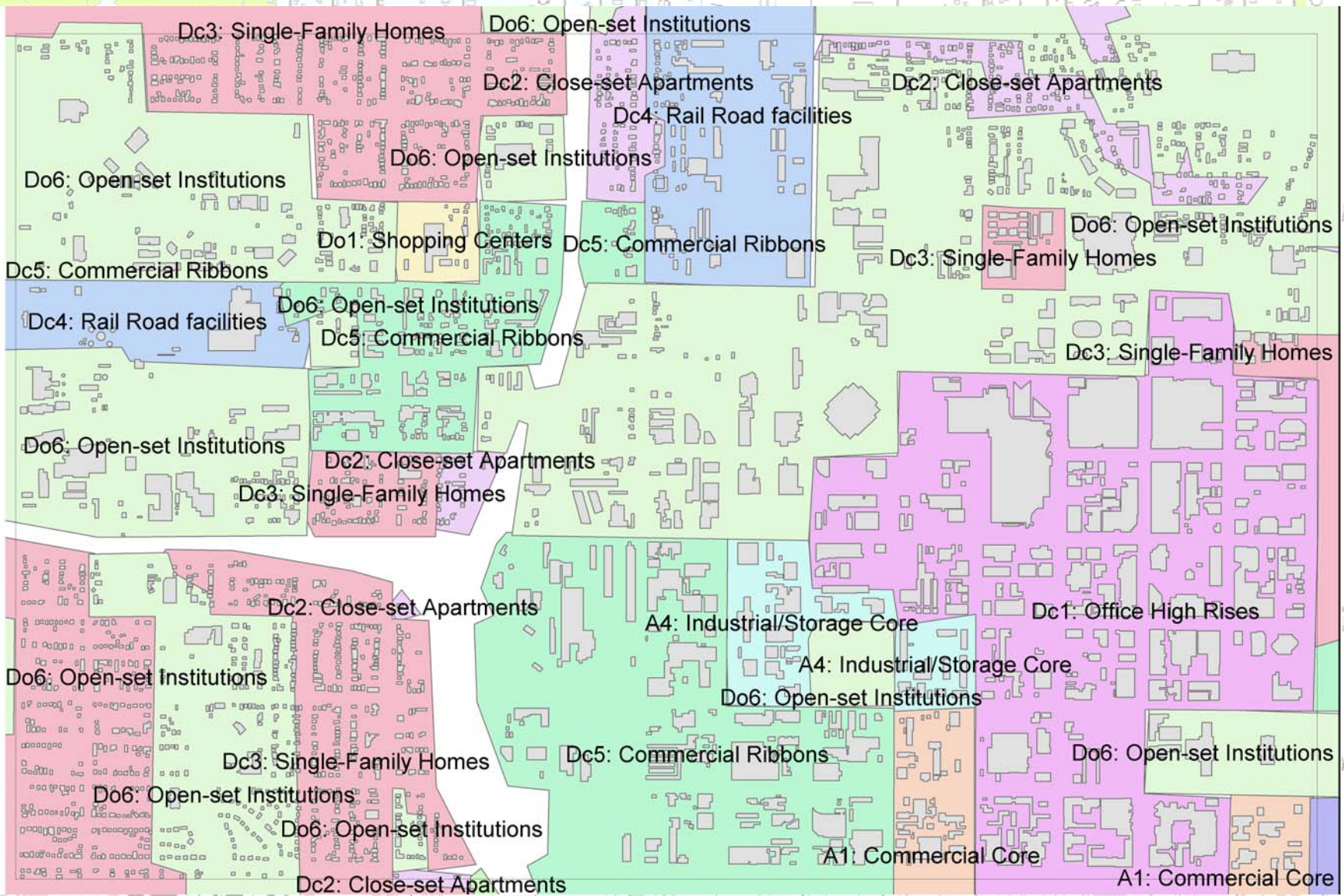
- A Classification system based on function and spacing[1].
- Areal Features which enclose buildings of similar size, spacing, and function.

Function	Attached (A)	Discrete Clustered (Dc)	Discrete Open (Do)
1. Commercial core	A1	Dc1	Do1
2. Apartments	A2	Dc2	Do2
3. Single-family Homes	A3	Dc3	Do3
4. Industrial	A4	Dc4	Do4
5. Commercial Ribbons	A5	Dc5	Do5
6. Institutional	A6	Dc6	Do6
7. Former Agricultural		Dc7	
8. Shanty Towns		Dc8	



[1] Developed by J. Liu, and Richard Ellefsen.
Small business innovative research, Phase II: Final scientific and technical report, Volume 1 and volume 2: UTZ-based urban terrain feature database. Sunnyvale, CA: TERA Research Incorporated, 1996.

UTZs, a Larger Example



Attribution Inferencing

- Given UTZ and building footprint area, generate attribution
  - Height, construction type, surface material composition, etc.

  with frequency distributions characteristic of a real city
- Appropriately deal with outliers
- Clustering algorithm classification method
  - Optimally clusters building areas within each UTZ
  - “K-means” – minimizes total withing-cluster variance
  - Known as “Jenks’ Method” in geospatial community

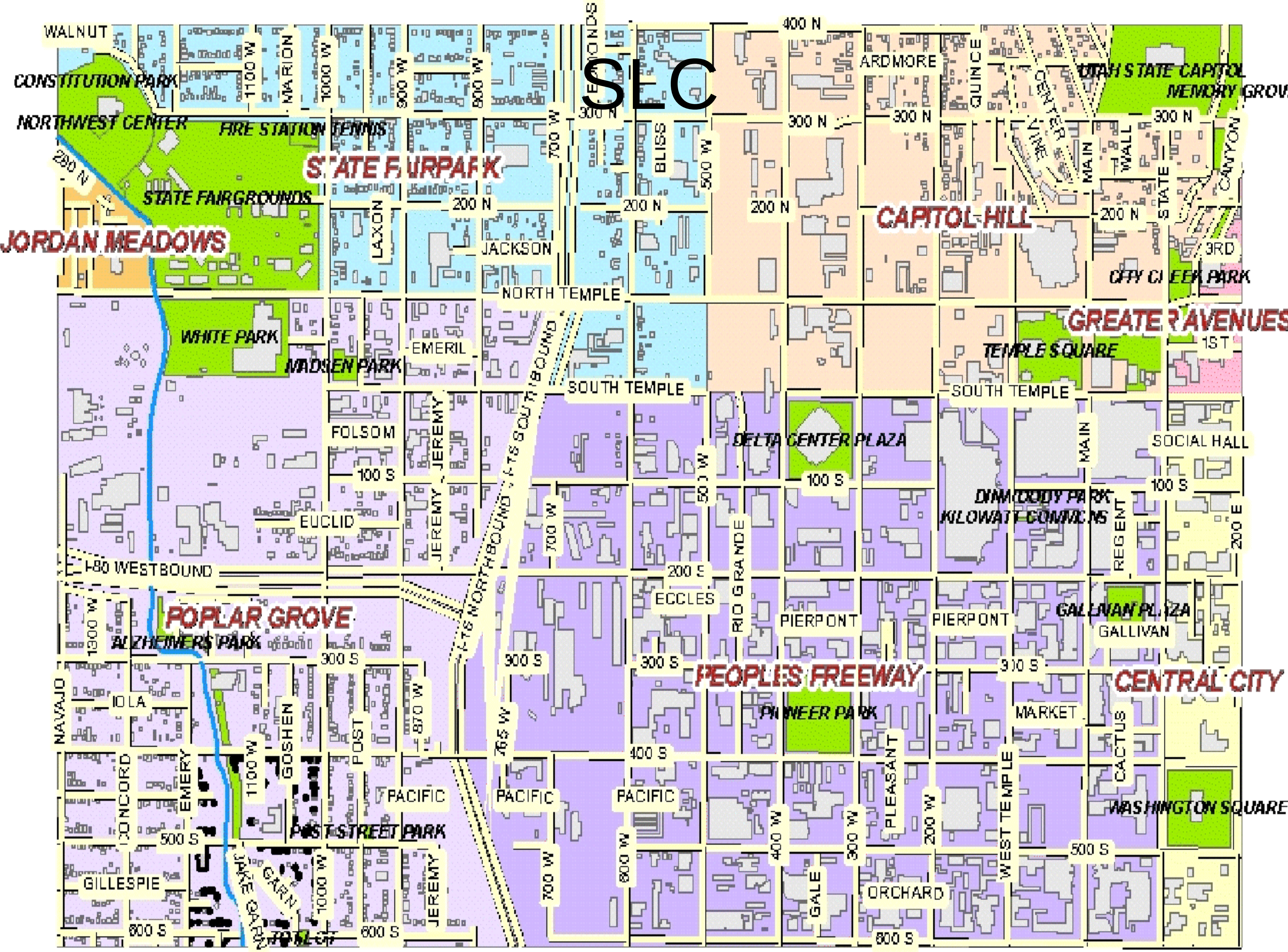
Attribute Inferencing Algorithm

1. For the world (off-line)
   - Prepare table of “adjacent UTZs”
2. For the city being modeled (off-line)
   - Generate statistics over all UTZ polygons of (each) given type, producing
     - 5 Jenks’ classes clustering building footprint area
       - Recording min/max/mean/std deviation
   - Assignment of “core classes”
     - To deal with outliers
     - Optional user intervention

Attribute Inferencing (continued)

3. For each Building
   - From UTZ and area, lookup Jenks' class
     - If class is "core", use class statistics
     - If class not core, (temporarily) re-assign UTZ via best match among adjacent UTZs
       - Find UTZ with a core class of similar footprint area
       - New UTZ must be semantically adjacent to original
       - Use class statistics of temporary UTZ and class

SLC



STATE FAIRPARK
JORDAN MEADOWS
CAPITOL HILL
GREATER AVENUES
POPLAR GROVE
PEOPLES FREEWAY
CENTRAL CITY
CONSTITUTION PARK
NORTHWEST CENTER
FIRE STATION TENNIS
STATE FAIRGROUNDS
WHITE PARK
MADSEN PARK
UTAH STATE CAPITOL
MEMORY GROVE
CITY CREEK PARK
TEMPLE SQUARE
DELTA CENTER PLAZA
KILOWATT COMMONS
GALLIVAN PLAZA
PIONEER PARK
WASHINGTON SQUARE
POST STREET PARK
NORTH TEMPLE
SOUTH TEMPLE
I-80 WESTBOUND
I-15 NORTHBOUND
I-15 SOUTHBOUND
400 N
300 N
200 N
100 S
200 S
300 S
400 S
500 S
600 S
1100 W
1000 W
900 W
800 W
700 W
500 W
400 W
300 W
200 W
WALNUT
MARION
ARDMORE
QUINCE
CENTER
VINE
MAIN
WALL
STATE
CANYON
BLISS
LAXON
JACKSON
EMERIL
FOLSOM
JEREMY
EUCLID
ECCLES
RIO GRANDE
PIERPONT
GALLIVAN
MARKET
REGENT
CACTUS
SOCIAL HALL
200 E
3RD
1ST
NAVAJO
IOLA
CONCORD
EMERY
GOSHEN
POST
870 W
765 W
PACIFIC
GILLESPIE
JAKE GARN
GARN
PLEASANT
WEST TEMPLE
GALE
ORCHARD
1300 W

Actual LIDAR Heights

Case 1: Fully Random

- "Flat Histogram"
- Min, Max, taken from original LIDAR heights
- Mean = Std. Dev. = ½(Max – Min)
- Looks like utter chaos

Case 1: Fully Random

The Real SLC

Case 2: One UTZ Polygon

- Min, Max, Mean AND Std. Dev taken from LIDAR heights.
- Low mean and std. dev for the entire dataset “flattens” all buildings.

Case 2: One UTZ Polygon

The Real SLC

Case 3: Multiple UTZs

- Min, Max, taken from LIDAR data, for each UTZ polygon
- Each UTZ has a "flat" distribution (Mean = STDEV = ½(Max – Min)
- "Neighborhoods" of similar heights start to form, but the suburbs have some "towers" and there's little differentiation between office hi-rise vs. warehouse

Case 3: Multiple UTZs

The Real SLC

Case 4: Accurate Mean, STDEV

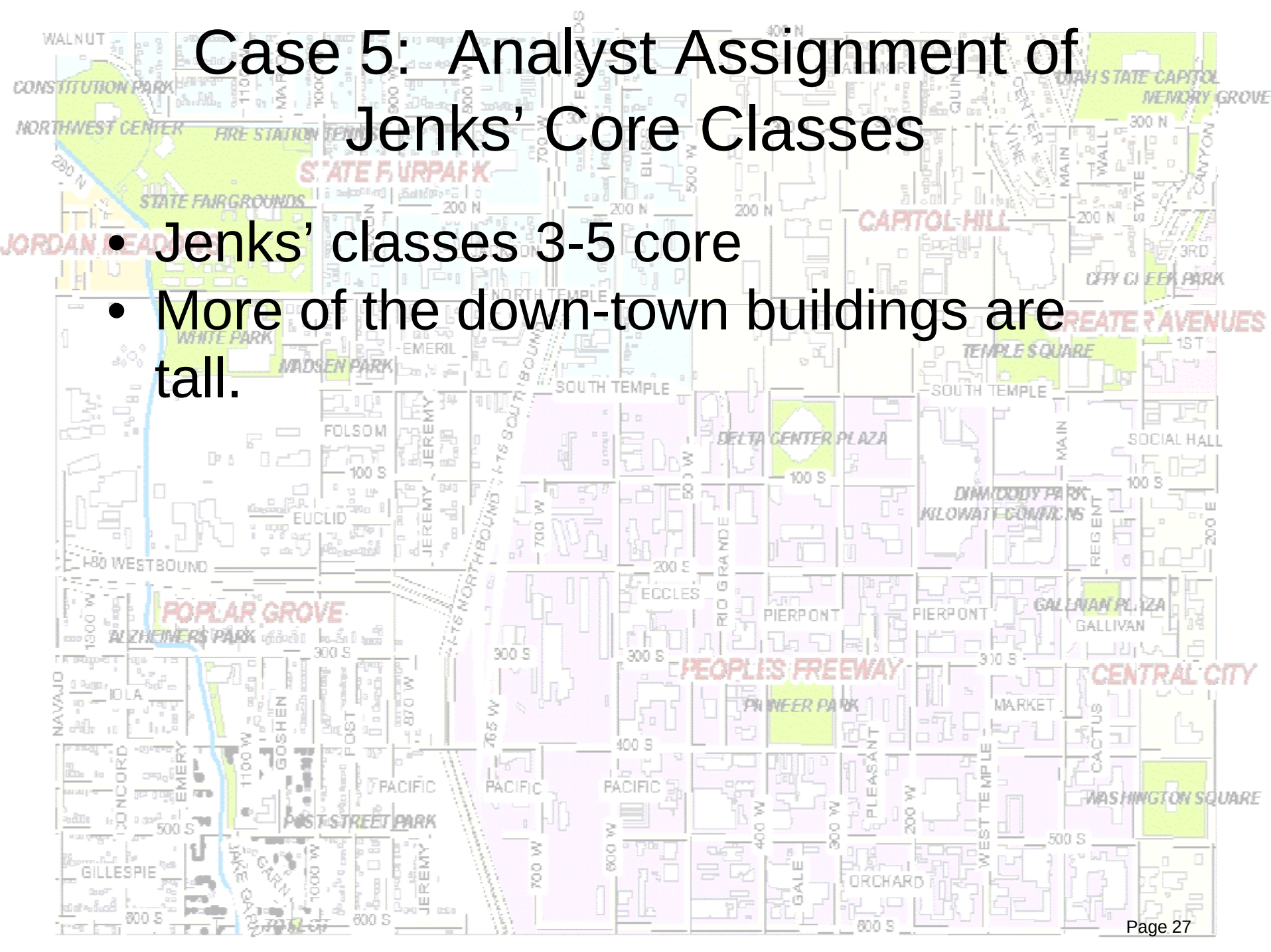
- Min, Max, Mean, Stdev all computed from LIDAR data, on a per-UTZ basis.
- All Jenks classes accepted as core, all building remain in their UTZs.
- Looking more city-like

Case 4: Accurate Mean, STDEV

The Real SLC

Case 5: Analyst Assignment of Jenks' Core Classes

- Jenks' classes 3-5 core
- More of the down-town buildings are tall.



Case 5: Analyst Assignment of Jenks' Core Classes

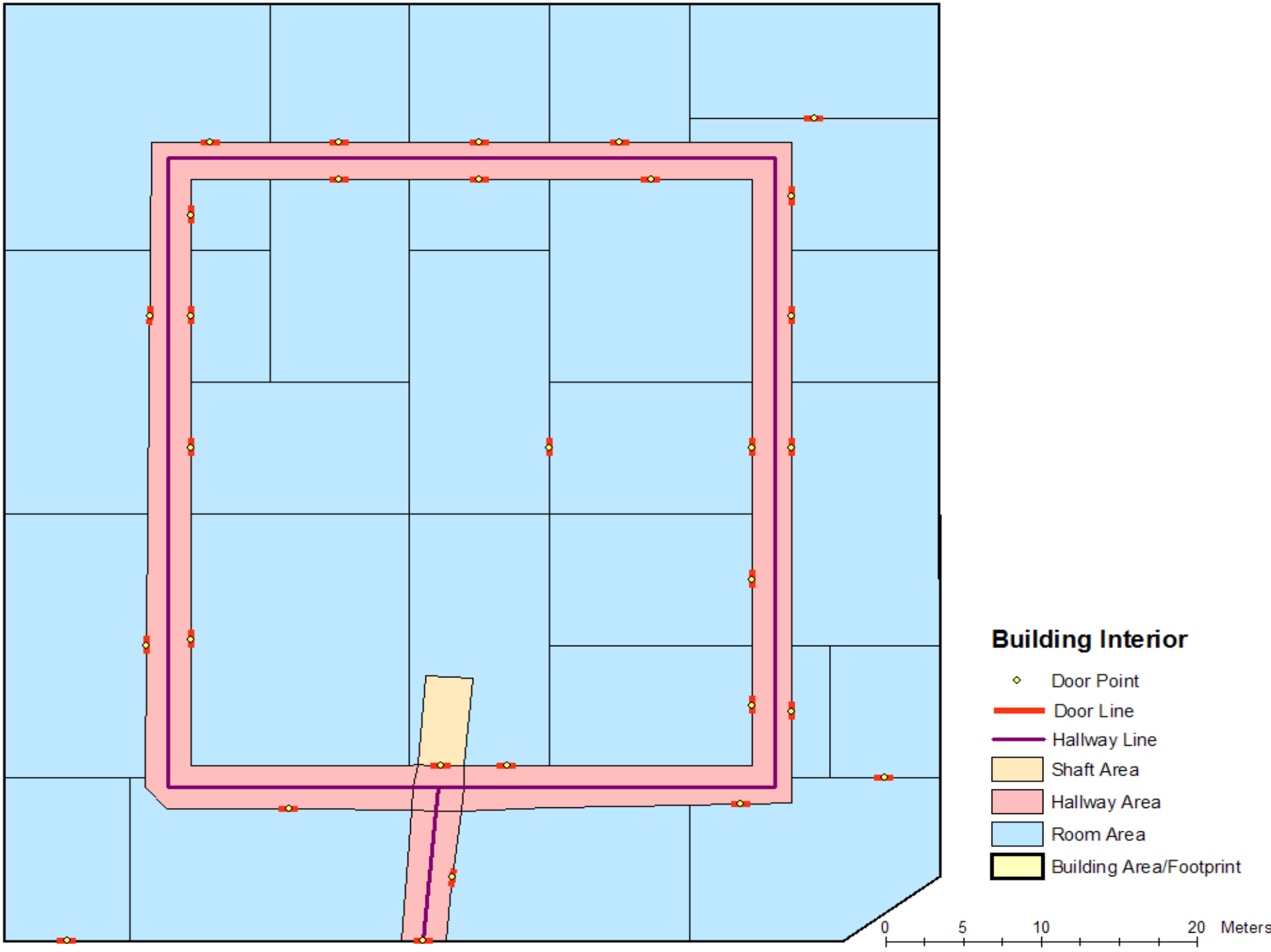
The Real SLC

Case 5: Analyst Assignment of Jenks' Core Classes

The Real SLC

Interior Configuration

- Literature replete with automated layout software
  - Non-linear optimization, not scalable
- Ad hoc process
  - Door near road
  - Linear or circular hallway depending on footprint size and aspect ratio
  - Shaft off hallway
  - Room filling


Building Interior
Door Point
Door Line
Hallway Line
Shaft Area
Hallway Area
Room Area
Building Area/Footprint
0
5
10
20
Meters

Geospecificity